



Impacts of Climate Change on Oceans

The Honorable Dr. Jane Lubchenco

Under Secretary of Commerce for Oceans and Atmosphere
& NOAA Administrator

National Oceanic and Atmospheric Administration | NOAA



Outline

Science and Society

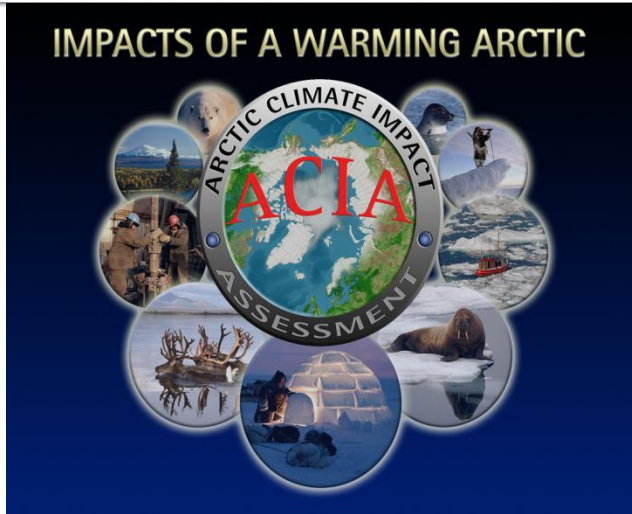
Global Changes in Oceans

Climate Impacts

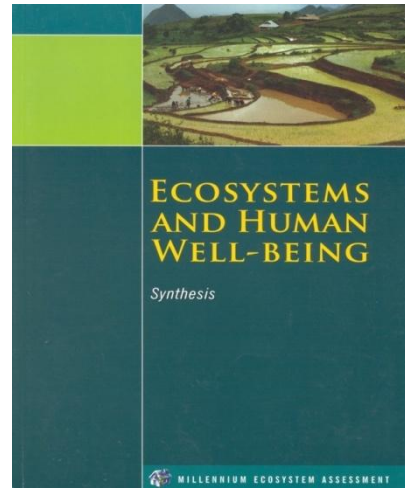
- 🌊 Predicted
- 🌊 Surprises



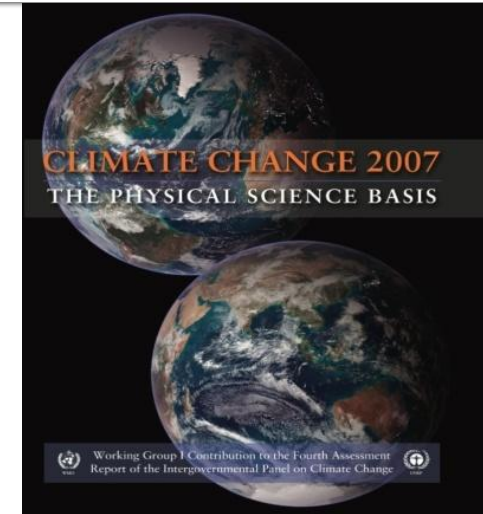
International Scientific Assessments



Arctic Climate Impact Assessment, 2005



Millennium Ecosystem Assessment, 2006



Intergovernmental Panel on Climate Change, 2007

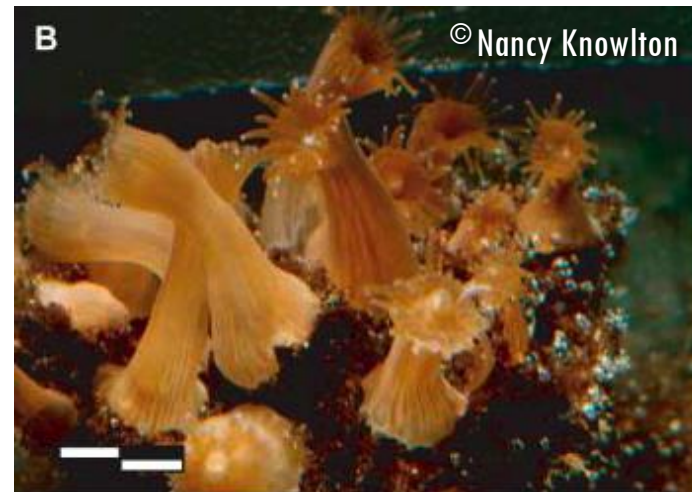
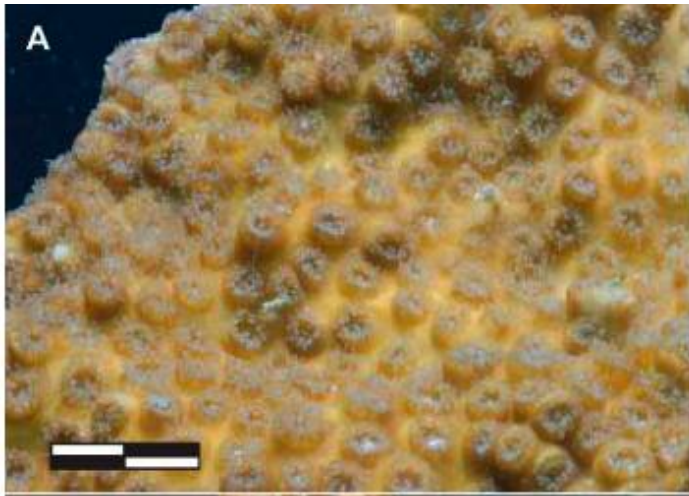
Global Climate Change Impacts in the United States, 2009



Global ocean trends

Depletion and disruption of ocean ecosystems

Loss of resilience (increased likelihood of abrupt changes)



Ocean acidification effect on coral:

(A) healthy coral with skeleton

(B) coral polyps without skeleton—unable to build reef

Ocean Ecosystem Services At Risk

Provisioning

- ✓ seafood
- ✓ habitat
- ✓ fuel wood
- ✓ genetic resources

Cultural

- ✓ spiritual
- ✓ recreational
- ✓ aesthetic
- ✓ educational

Regulating

- ✓ climate regulation
- ✓ disease & pest regulation
- ✓ coastal protection
- ✓ detoxification
- ✓ sediment trapping

Supporting

- ✓ Nutrient cycling
- ✓ Primary production

Causes

Overfishing, destructive fishing

Pollution, especially nutrient pollution

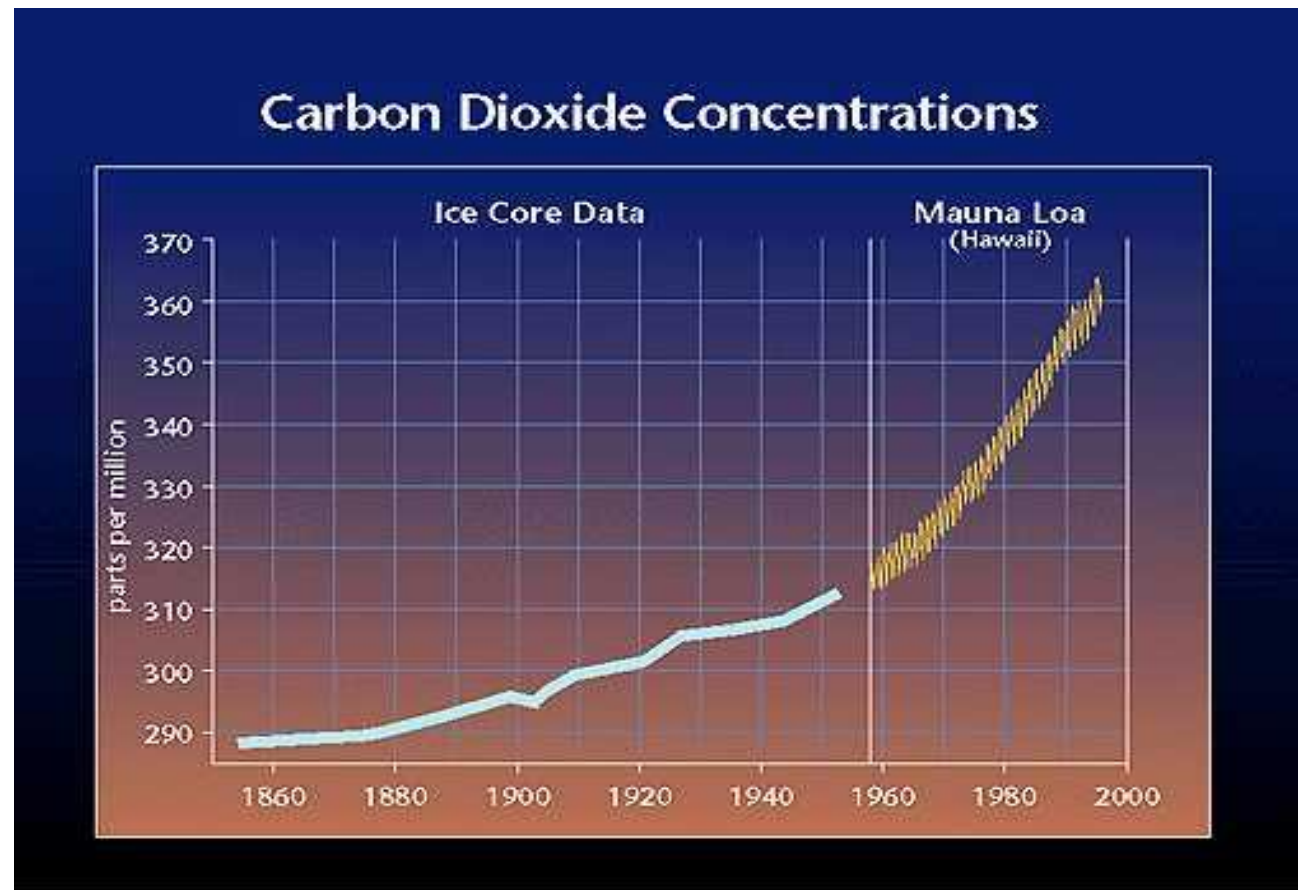
Coastal development: loss of critical coastal habitats

Climate change and ocean acidification

Climate Change and Oceans

Expected (predicted) changes

Surprises



Predicted Physical Changes

Oceans temperatures will increase

Sea level will rise

Ocean circulation may change

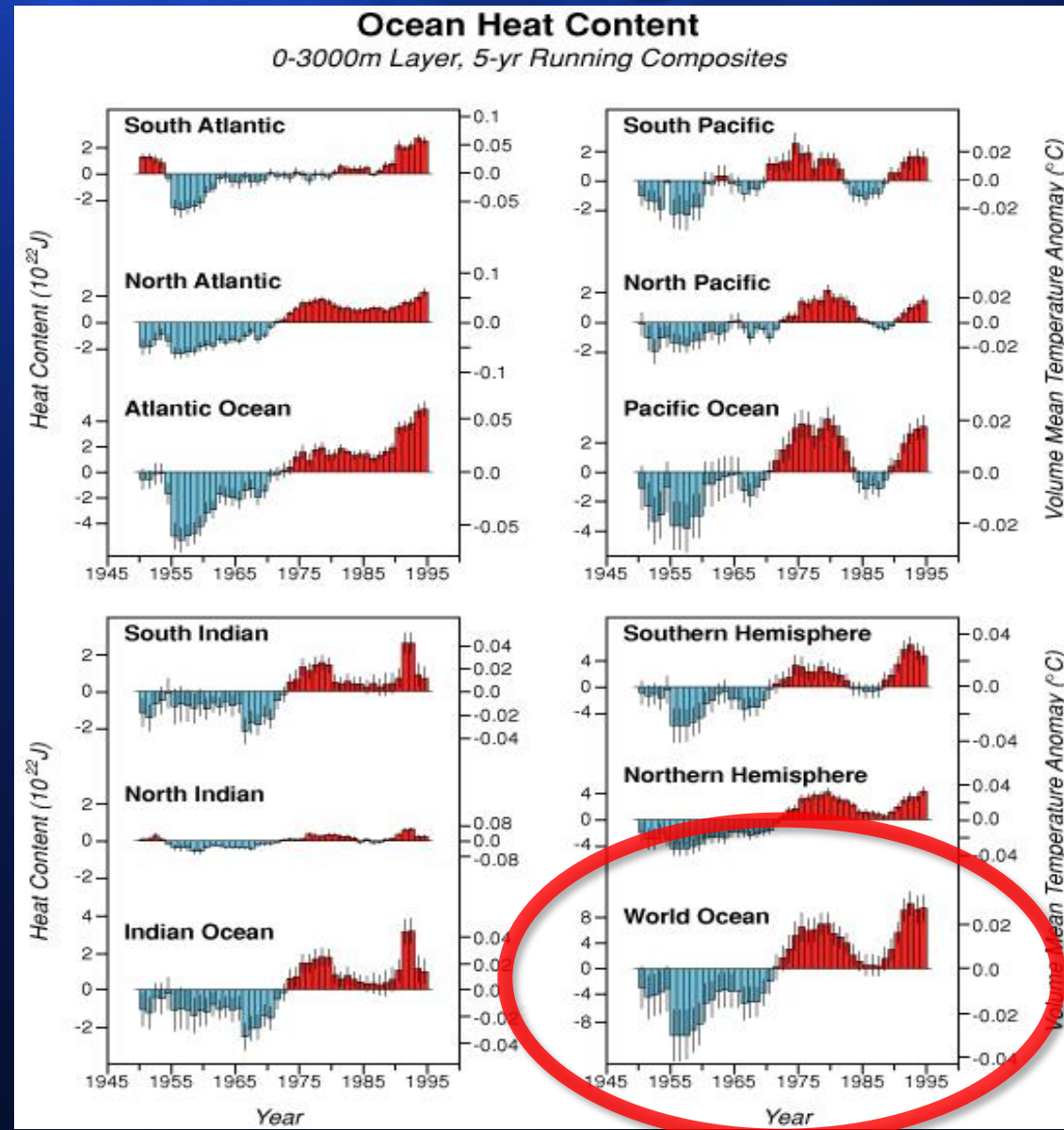
Wave height

Storminess

The Oceans Are Warming

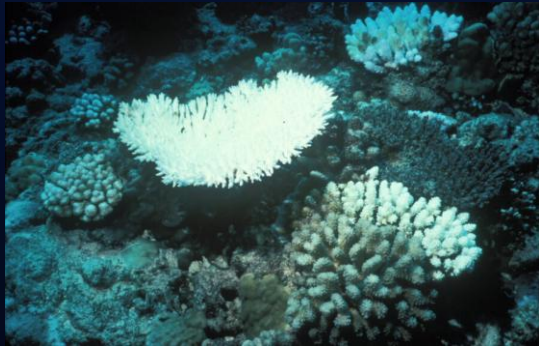
The heat content of the oceans increased in the 2nd half of the 20th century

Levitus et al., 2000

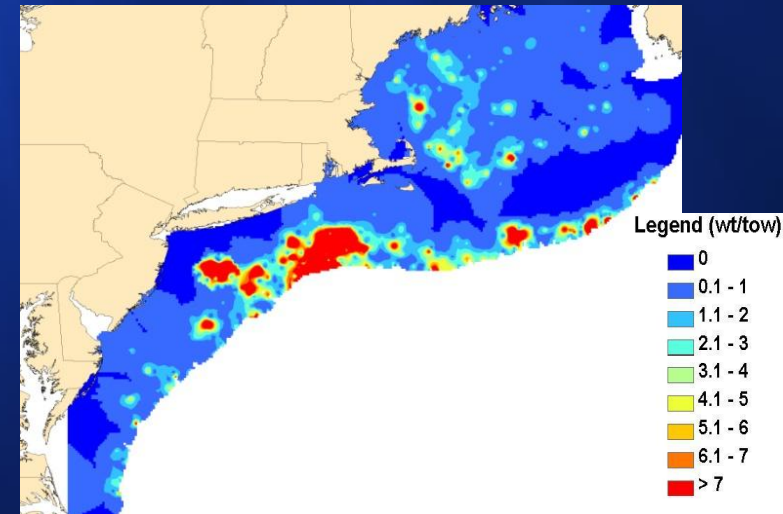


Biological Consequences of Warming Oceans

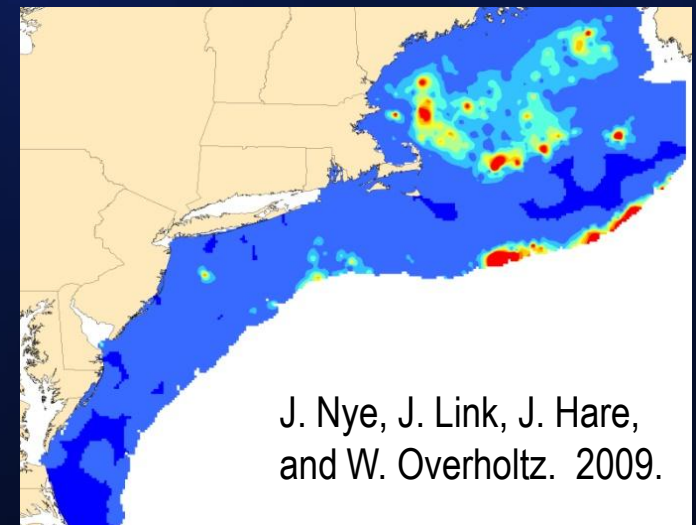
- a) Corals are bleaching
- b) Arctic Sea ice is melting
- c) Many species are shifting ranges or are at risk of extinction



Red Hake 1968-72

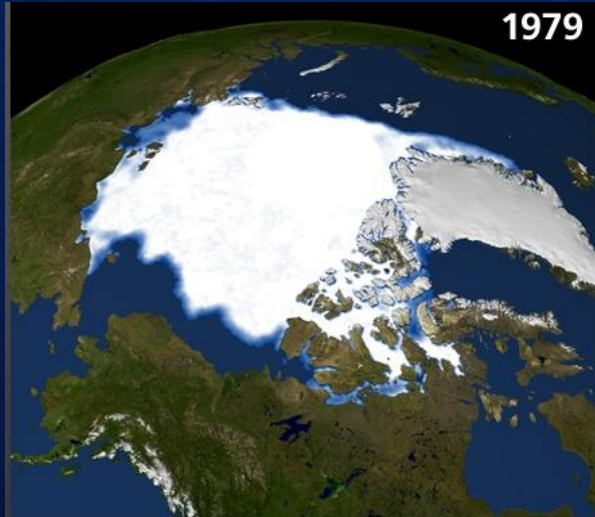


Red Hake 2003-2007

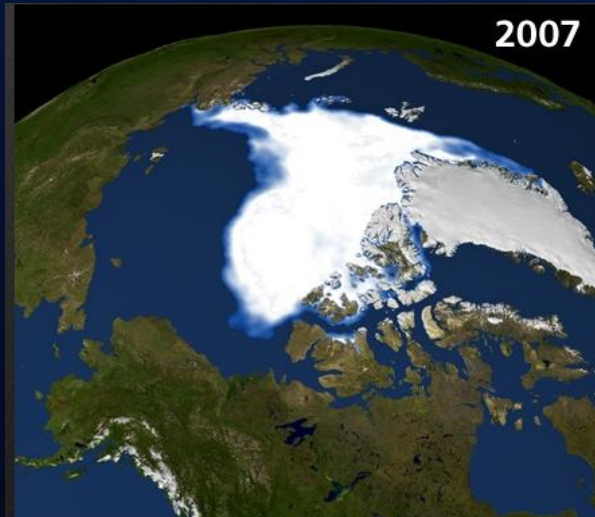


Arctic Sea Ice Extent

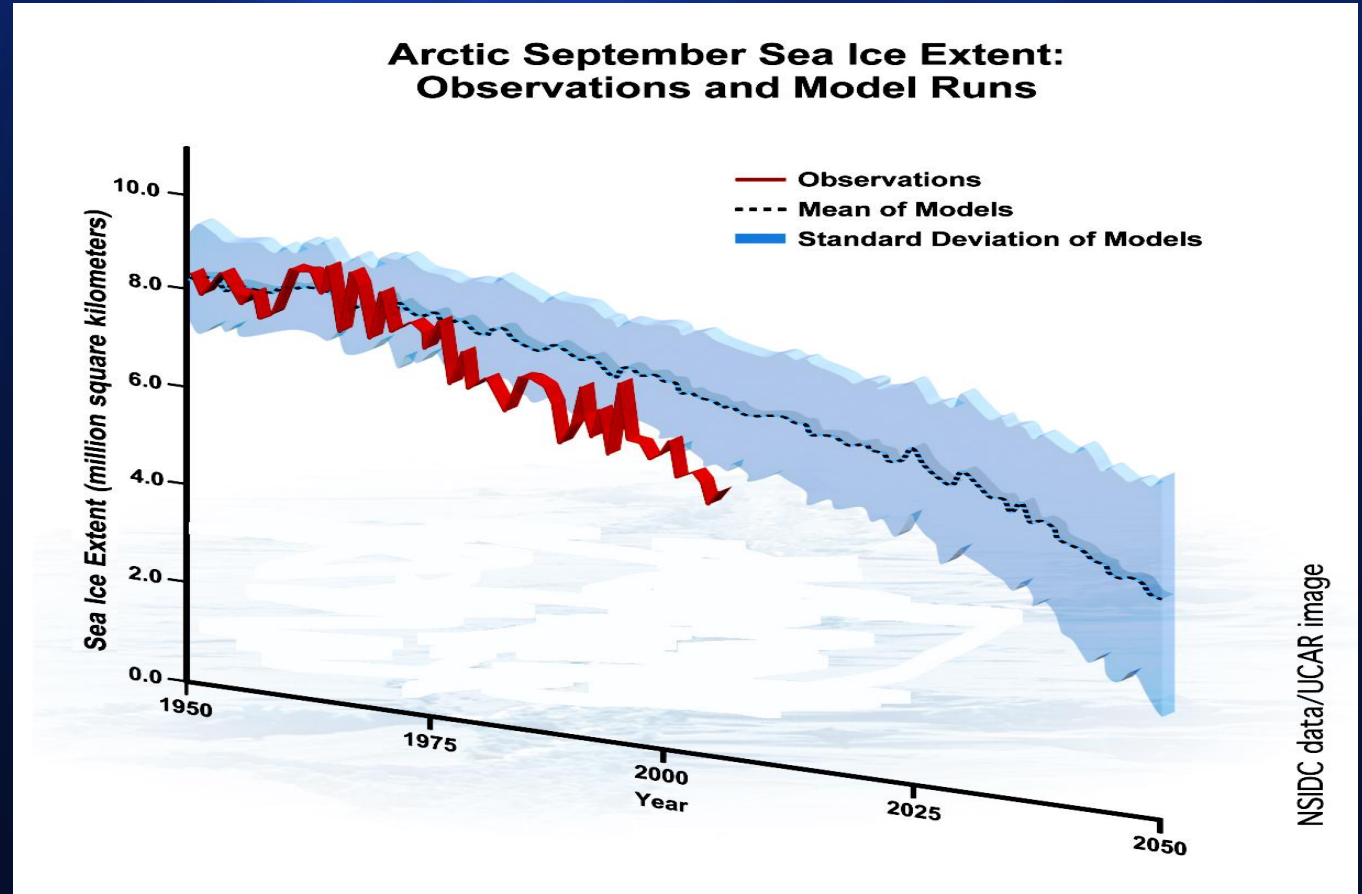
Annual Average



1979



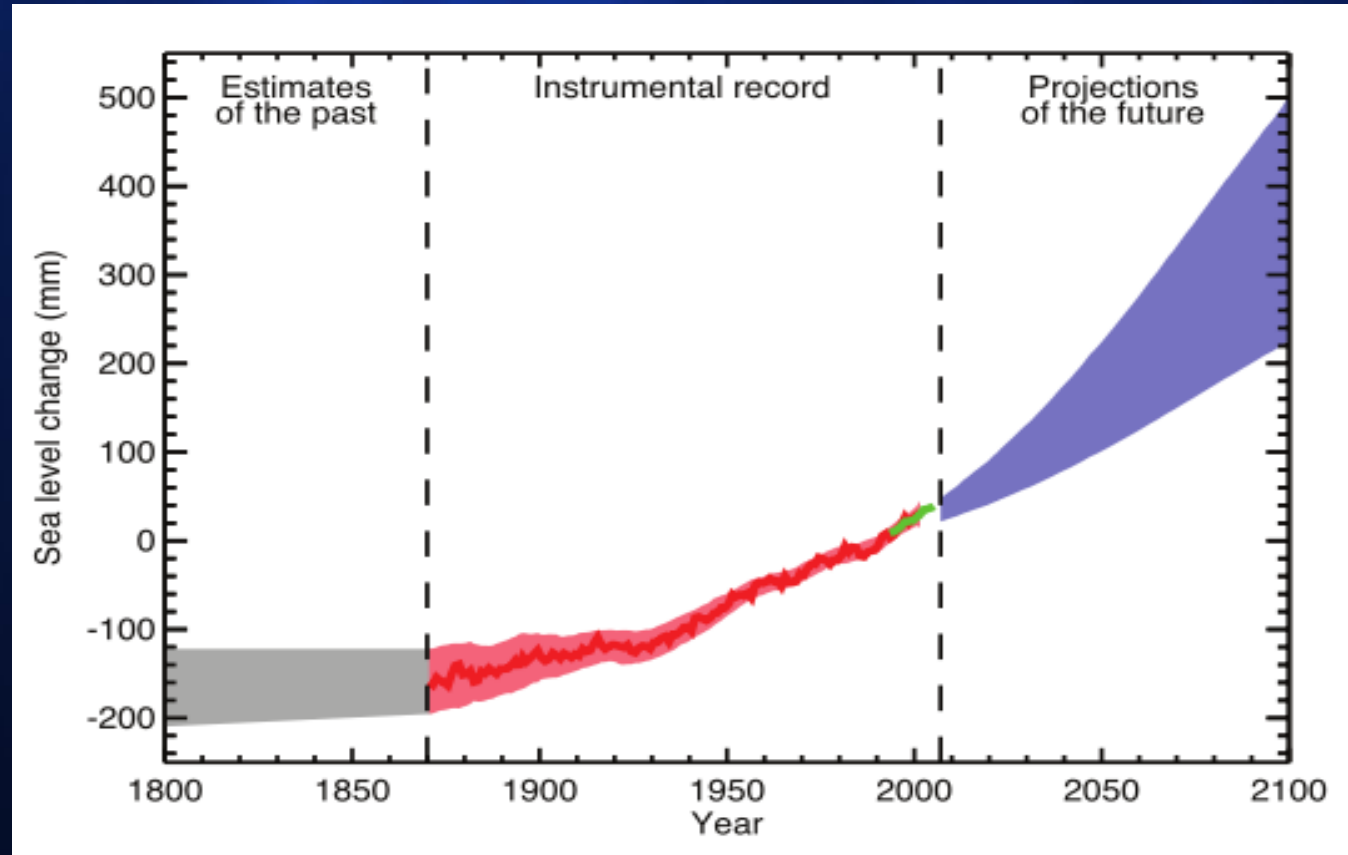
2007



Sea-level Rise Is Accelerating And Is Expected To Continue To Rise

Due to

- 1) Thermal expansion
- 2) Melting from glaciers, ice caps
- 3) Melting ice sheets



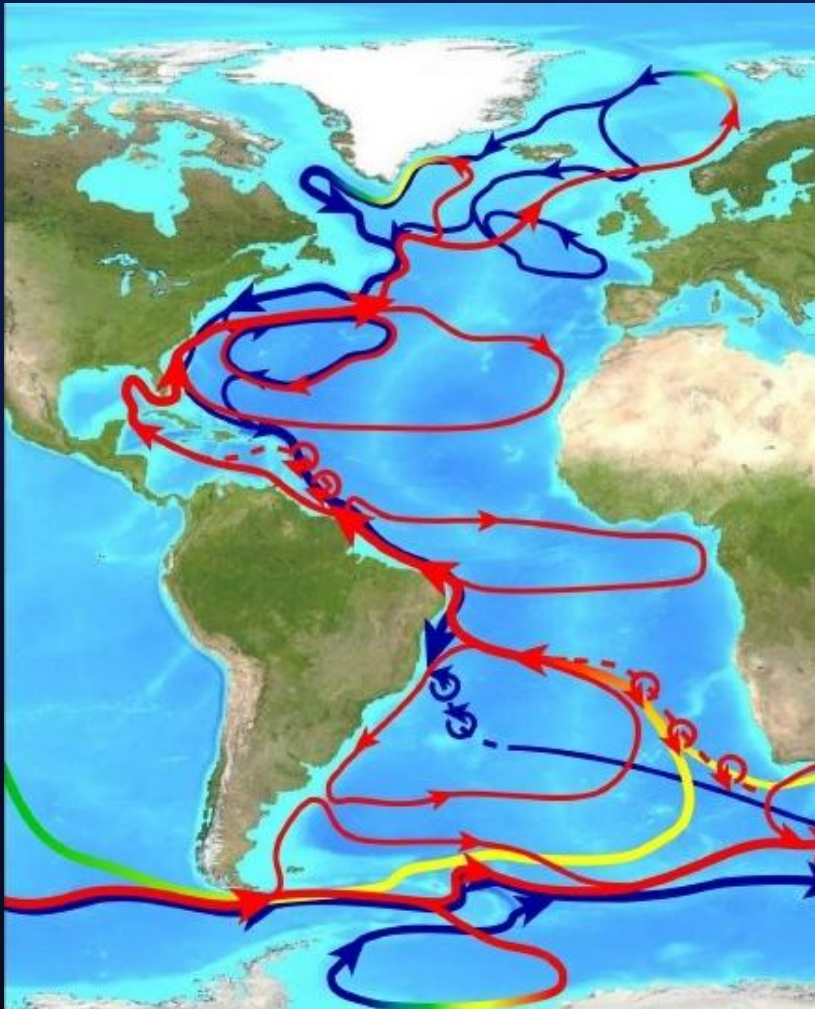
IPCC 2007

Rising Sea Levels Increase Coastal Vulnerability

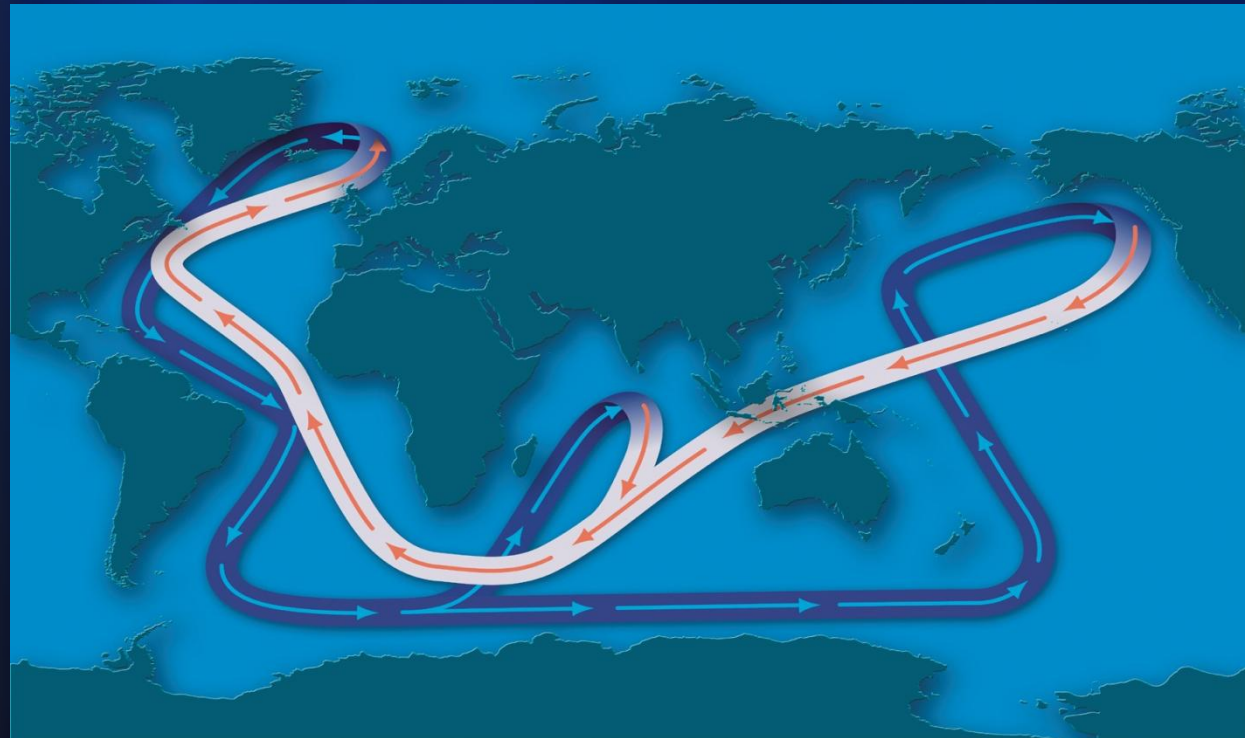


*Lidar-derived elevation data
for Charleston South Carolina*

Large Scale Ocean Circulation Could Change



*'If' and 'When' are
not known*



Summary: Predicted Physical Changes

- 1) Ocean temperatures will increase
- 2) Sea level will rise
- 3) Ocean circulation may change

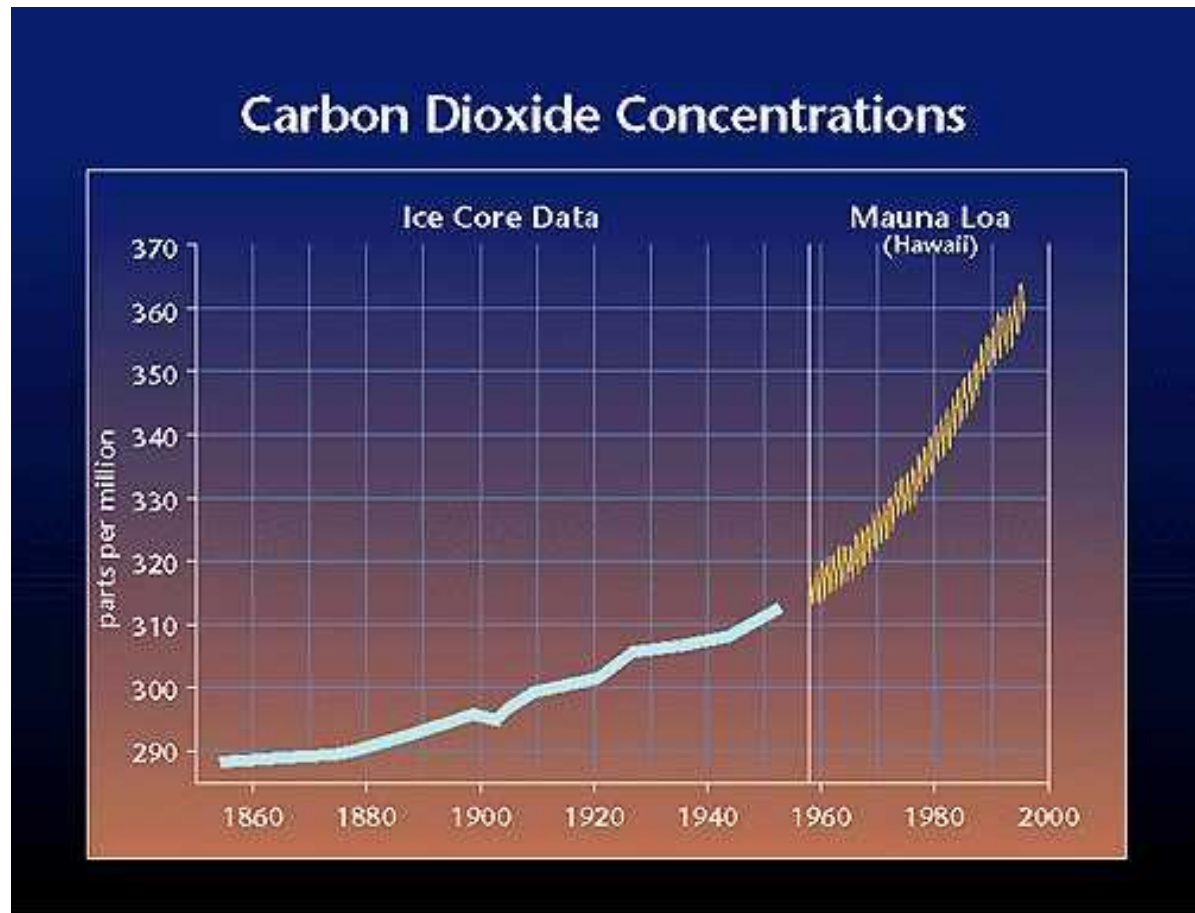
***1 & 2 are happening,
faster than expected;
3 is possible
but highly uncertain***

Climate Change Impacts On Ocean Ecosystems

Expected (predicted) changes

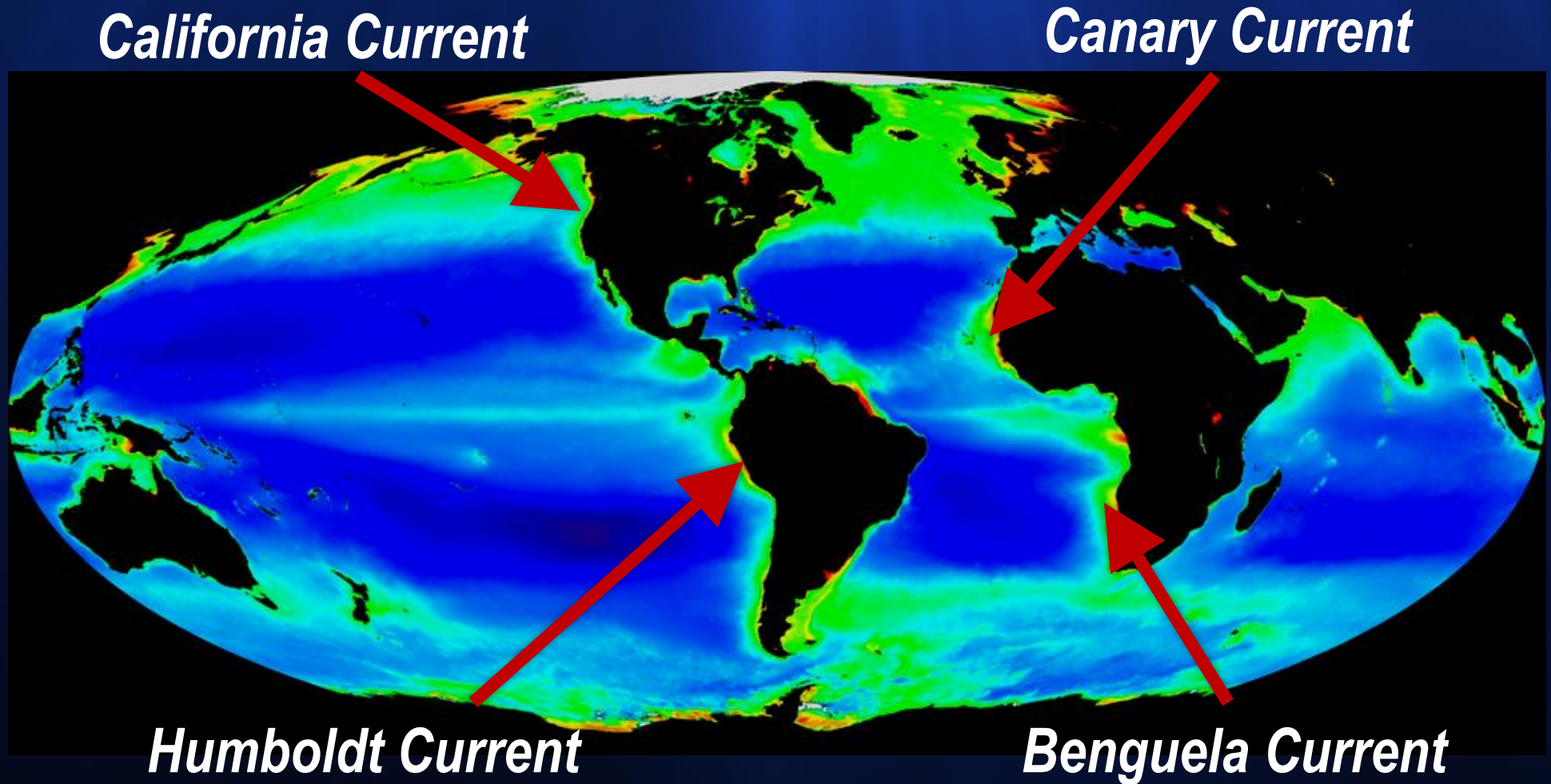
Surprises

- 1) Coastal upwelling dynamics
- 2) Dissolved Oxygen
- 3) Ocean Acidification



Changes in Coastal Winds & Upwelling

1% surface area; 20% of fisheries

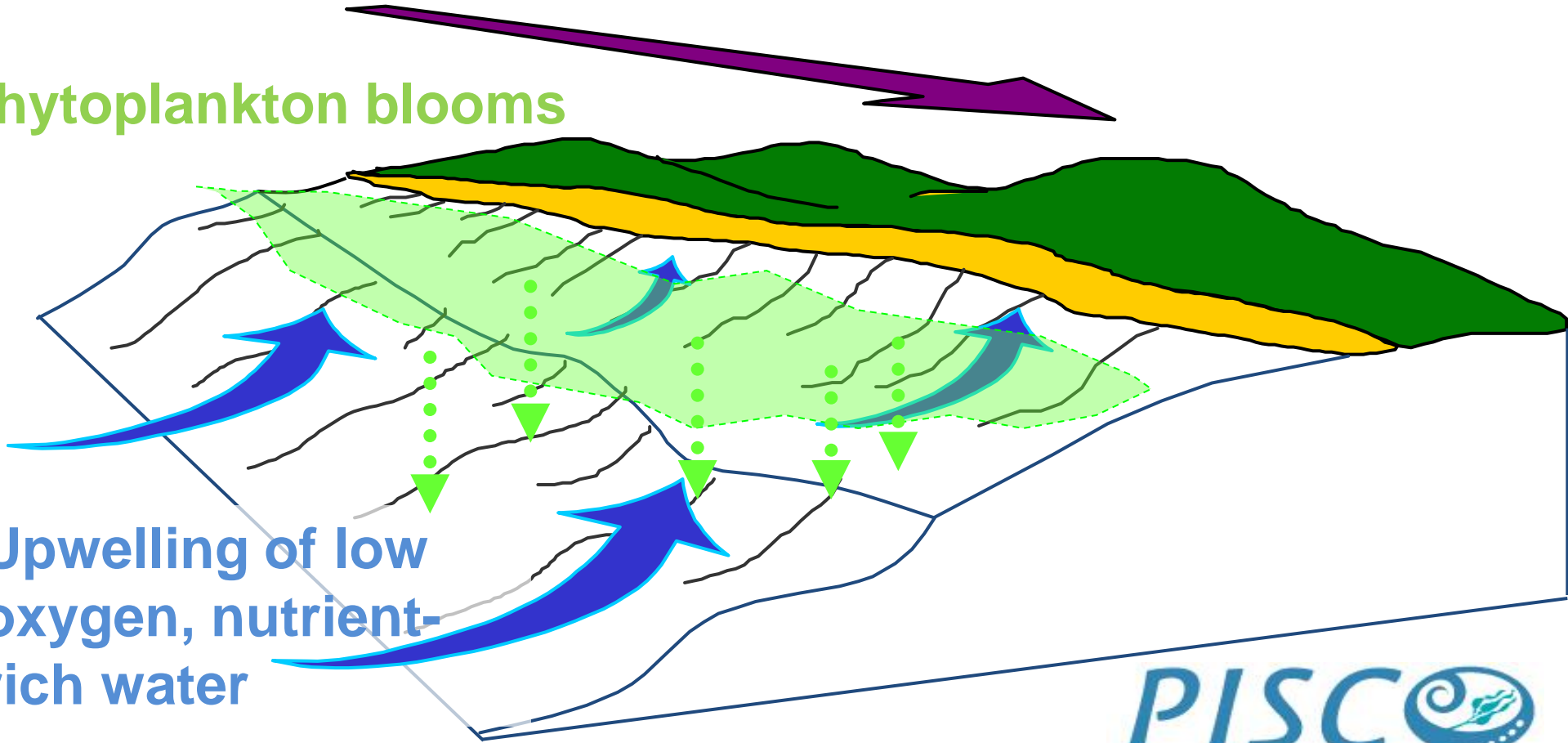


What Causes Hypoxic Zones To Form Along Coasts?

1. Equatorward Winds Drive Upwelling Currents

3. Phytoplankton blooms

2. Upwelling of low oxygen, nutrient-rich water

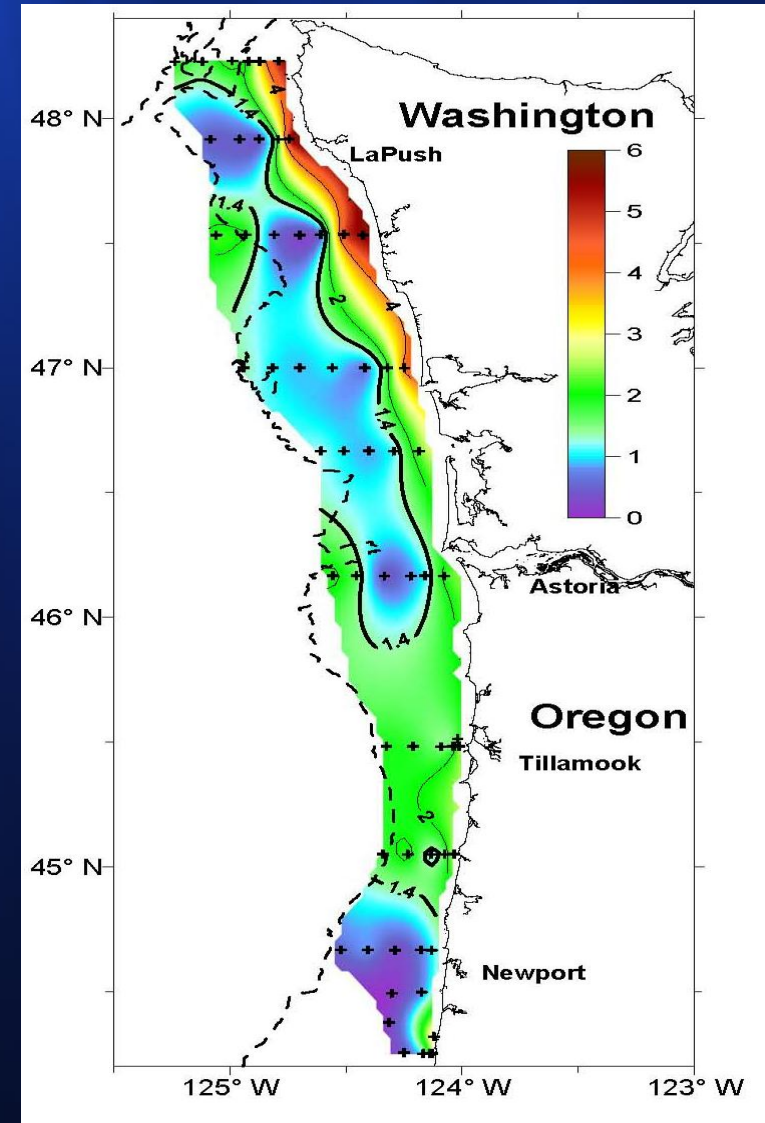


PISCO

Result: 8 hypoxia events in 8 years along the Oregon and Washington coast (2002-2009)



September 20-28, 2006 BPA
and PISCO cruises
(Figure Courtesy Bill Peterson,
Cheryl Morgan NOAA)



At Times 80% Of The Shelf Water Column was Hypoxic

2006:

- Longest lasting – 4 months
- Largest off Oregon and Washington
- Thickest ~2/3 of water column
- Most severe – anoxic = no oxygen

OSU glider

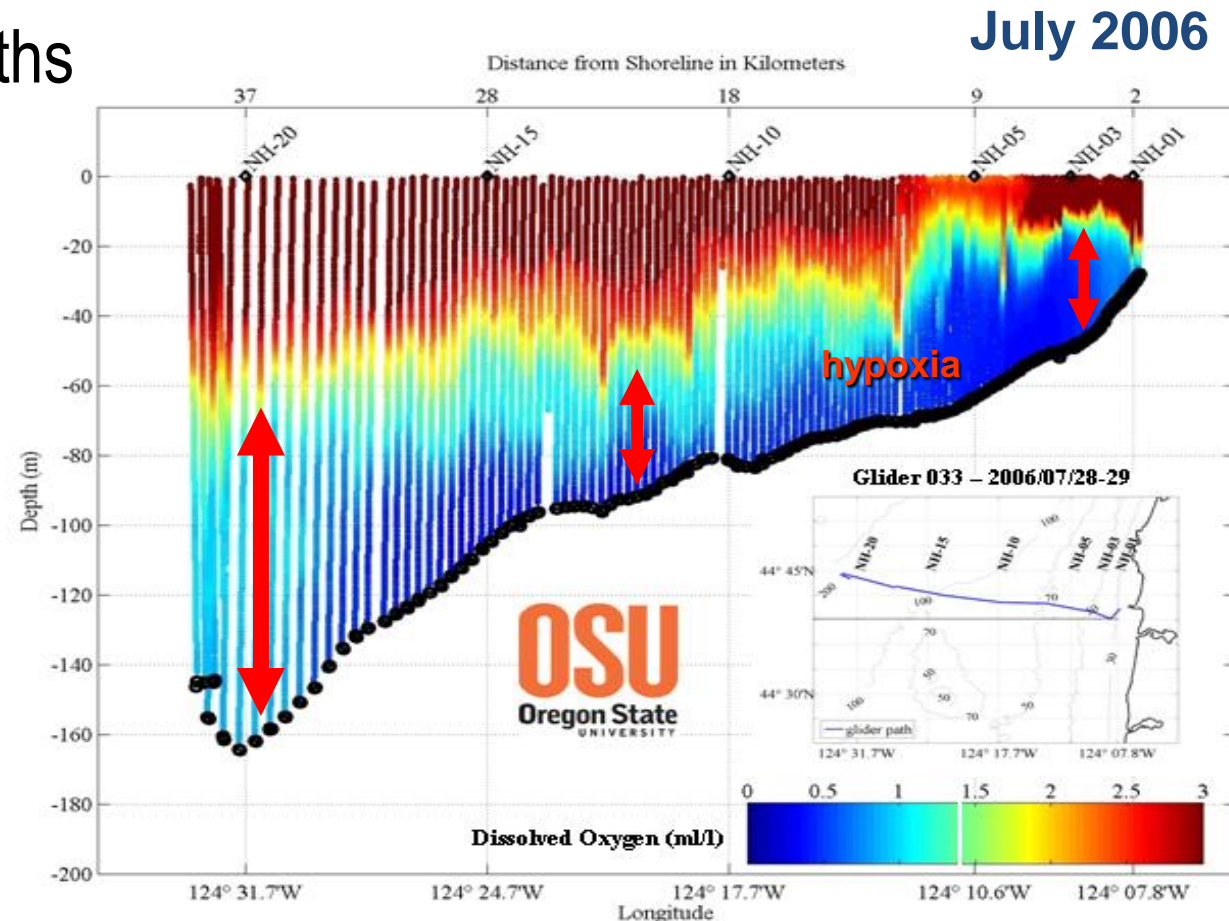
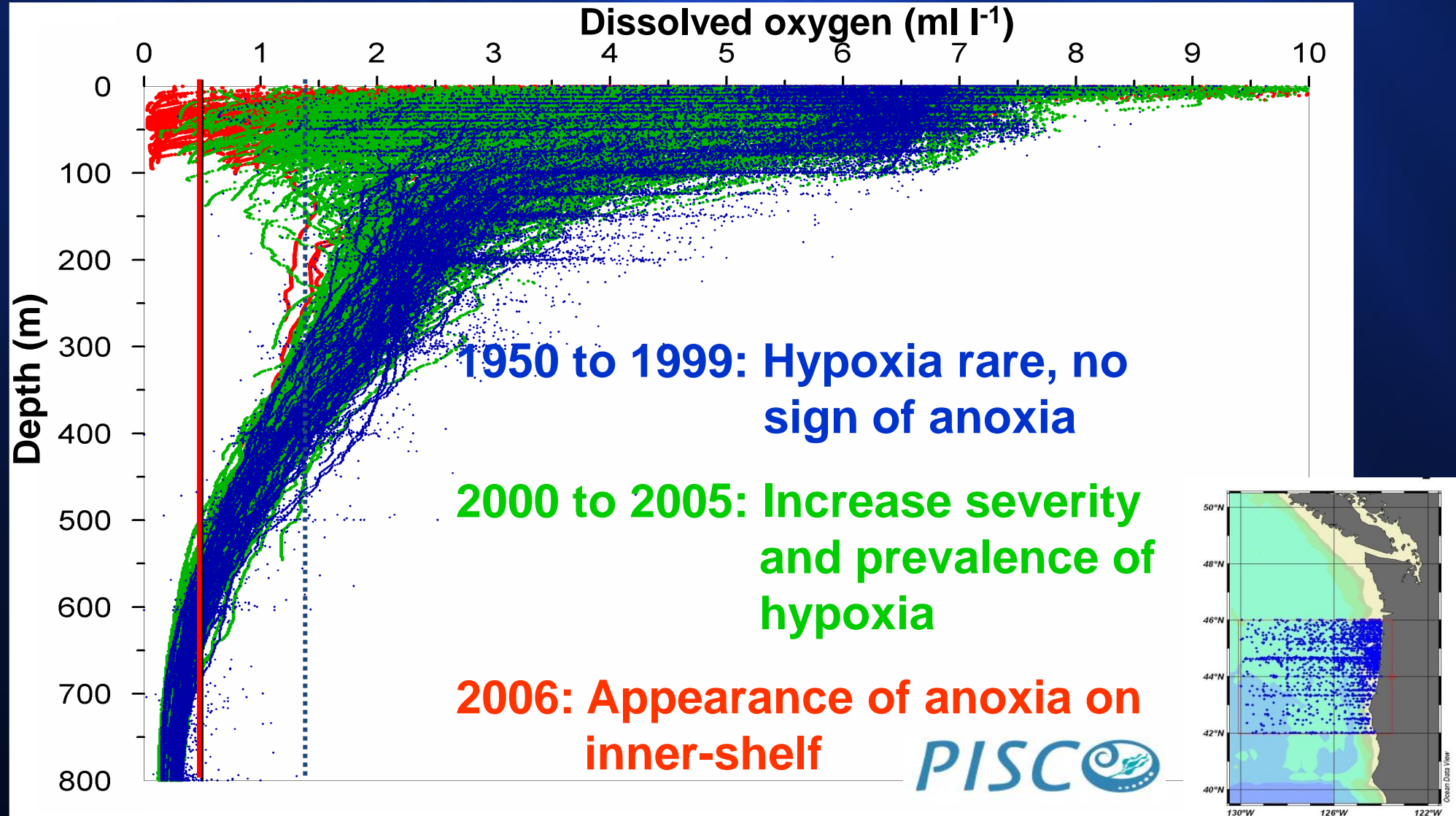


Figure: Jack Barth/ Kipp Shearman

2006 was highly anomalous



National Oceanographic Data Center, NOAA, OSU
Archives, GLOBEC LTOP, NOAA, PISCO

Chan et al. *Science* 2008

Impacts of Climate Change on Oceans

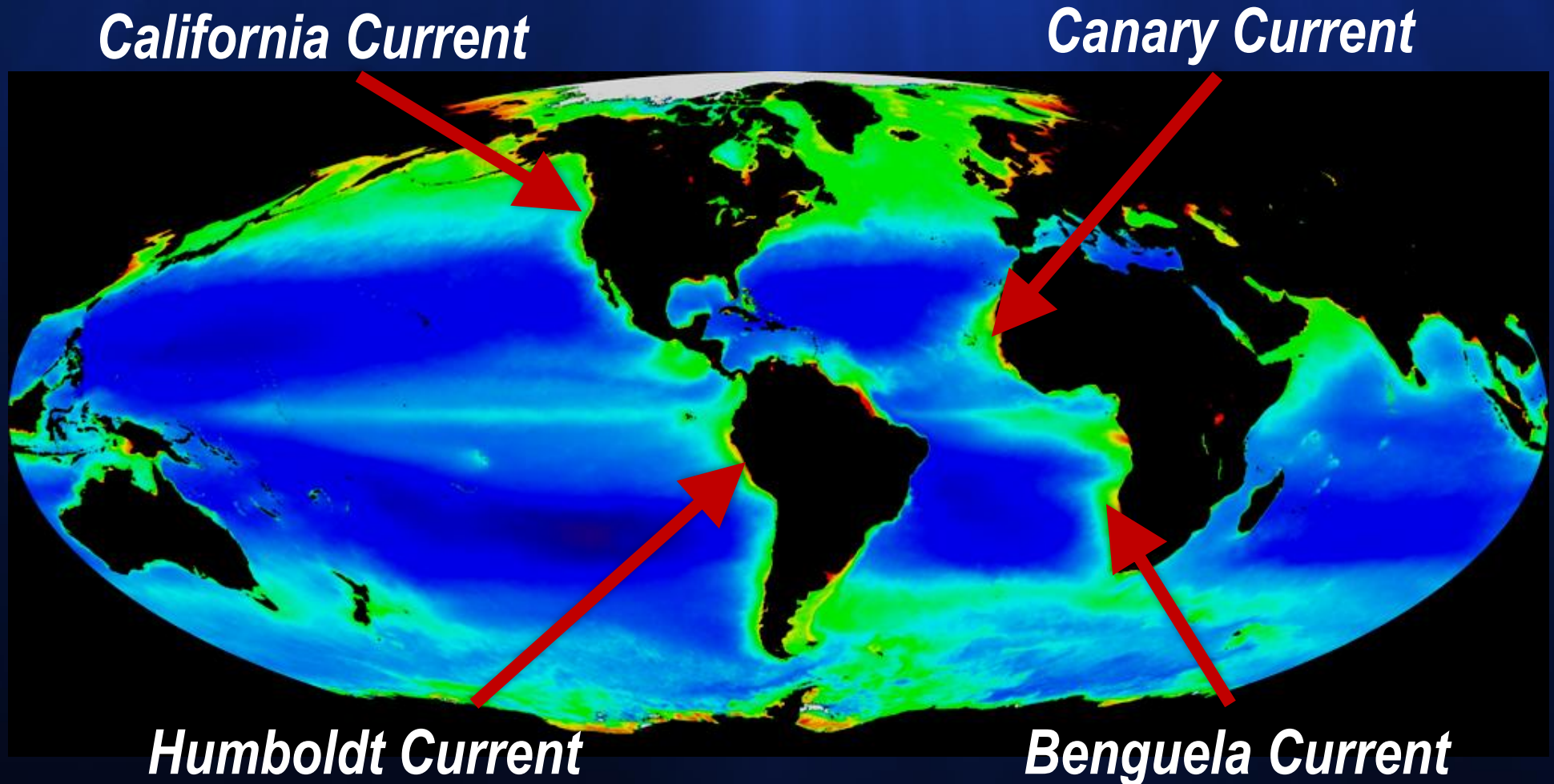
Working Hypotheses

Fundamental changes in ocean and atmospheric conditions in the California Current Ecosystem

Changes in ocean and atmospheric circulation may be a result of climate change

Changes in Coastal Winds & Upwelling

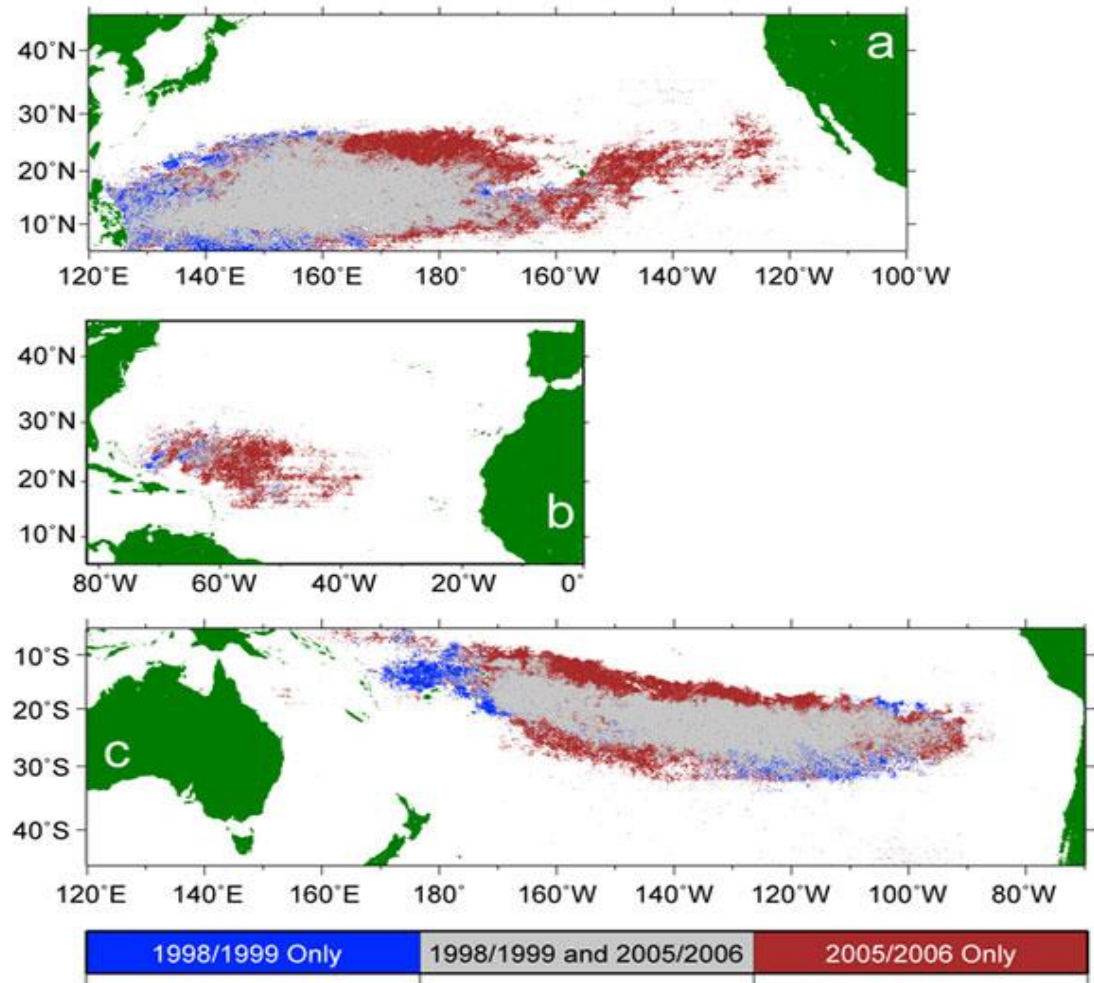
1% surface area; 20% of fisheries



Subtropical Gyres, The Oceans Least Productive Areas Are Expanding

Between 1998 and 2006, low productivity, oligotrophic areas expanded by 6.6 million km², or about 15%

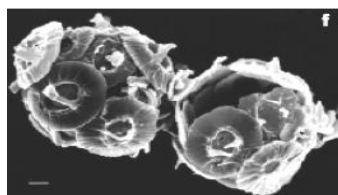
Rates of expansion already greatly exceed model predictions



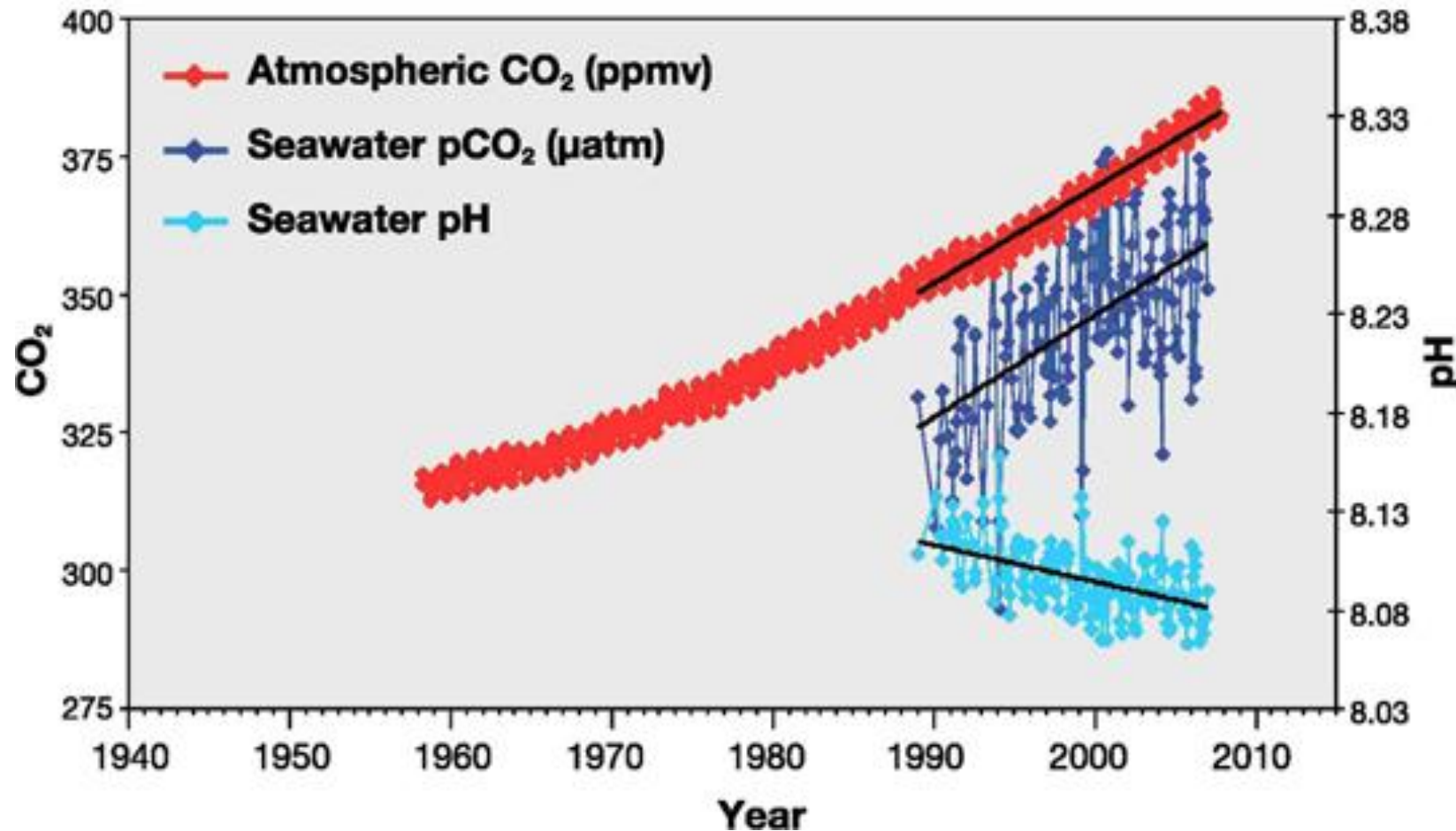
Polovina et al. 2008. *Geophysical Res. Let.* 35(3), L03618, doi:10.1029/2007GL031745

Ocean Acidification:

Climate Changes “Equally Evil Twin”






CO₂ and pH time series in the North Pacific Ocean



Adapted from Feely (2008) in Levinson and Lawrimore (eds), *Bull. Am. Meteorol. Soc.*, 89(7): S58.

Strategies to Minimize Impacts of Climate Change

Reduce stresses that can be controlled

-  Reduce nutrient and chemical pollution
-  Manage fisheries conservatively
-  Control invasive species

Protect biodiversity and habitats to maximize likelihood of adaption

Invest in scientific research, monitoring and education



Thank You!

The Honorable Dr. Jane Lubchenco

Under Secretary of Commerce for Oceans and Atmosphere
& NOAA Administrator

National Oceanic and Atmospheric Administration | NOAA



Rising Sea Levels Increase Coastal Vulnerability

**Charleston, South Carolina
1.0M Sea Level Rise**